

Appendix 18

Episode Selection for the 1993, 1996, 1997, & 1998 Ozone Season Using the EPA Method



Episode Selection for the 1993, 1996, 1997, & 1998 Ozone Season Using the EPA Method

The EPA's episode selection method in section 12 of the Draft Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-hr Ozone NAAQS was used to select ozone modeling Episodes in 1993, 1996, 1997, and 1998. In order for this method to be applied correctly, ozone data must be quality assured for the immediate year, before the year of interest, the year of interest, and the immediate year after the year of interest. Quality assured ozone data is available from 1992 through 1999.

Meteorological conditions vary greatly from year to year, having a major impact on ozone levels (Table I). Table I lists ozone categories from 1992 through 1999, showing the number of Yellows, Oranges, and Reds that occurred in South Carolina. The new EPA 8 hour standard breaks ozone levels up into four categories: low ozone values fall in the green category, 64 ppb or less in concentration; moderate levels of ozone, 65 ppb to 84 ppb, fall into the yellow category; the proposed 8hr standard is 85 ppb and this is where the Orange category begins; the red level represents very high ozone levels or 105 ppb or higher (red category). Adding the number of oranges and reds together in Table I results in the total number of exceedences of the new 8 hr ozone standard for all of the SC for the particular year of interest (listed in the right hand column). The total number of greens were omitted in Table I because the concern is with higher ozone levels. Table I shows a peak in ozone levels in 1993 then again towards the end of the period, in 1997 and especially in 1998. If the newly proposed 8hr standard was in affect in 1993, South Carolina would have had seventy one hits of the 8hr standard. In addition, seven of those seven hits would have exceeded 105 ppb (red category). Eight hundred and ninety-eight monitored ozone levels were at least 65 ppb or higher (yellow category or higher). Lower ozone levels occurred in 1992, 1994, 1995, and especially in 1996. Based on the proposed 8 hr standard, only three exceedences of the standard would have occurred statewide during 1996. Since three years of ozone data are needed to calculate design values for a specific year, 1994, 1995, 1996, 1997, and 1998 were the best representative years in which to select ozone episodes in South Carolina because of the lower ozone levels. This analysis was conducted using the 1998 data found in the second half of this report. Because the ozone season of 1998 was the worst on season, the analysis yields a rich data set for ozone modeling. This combined with severer than normal ozone seasons in 1997 and 1999 resulted in exceptionally high design values for the 1998 ozone season. As one can see from Table I, 200 hits of the proposed 8 hr standard occurred in 1998, well surpassing the seventy one hits that occurred in 1993.

Table 1 Ozone Categories

Year	Yellows	Oranges	Reds
1992	113	6	0
1993	827	64	7
1994	387	43	0
1995	568	45	2
1996	139	3	0
1997	861	65	0
1998*	1089	190	8
1999	1072	149	5

Ozone Episode Selection for 1993

Meteorological conditions were ripe for the formation of ground level ozone during the summer months of 1993. A stagnant upper-level ridge of high pressure sat over the Southeast for much of the summer of 1993. Design Values were calculated for each monitor in 1993 using Step I in the EPA guidance in section 12. The design values for 1993 are listed below in Table II. The 1993 design value is calculated by averaging the 4th highest ozone value for each monitor from 1992, 1993, and 1994. Design values greater than 75 ppb (- 10 ppb of the 8 hr standard) are bolded in blue, while design values less than 75 ppb are bolded in black. Monitors with design values less than 75 ppb were excluded from the study; these monitors included Cape Romain and Congaree Swamp (see Table 2a).

Table 2a -Design Values for 1993- Step 1

Monitors	Design Value	Monitors	Design Value
Cape Romain	72	Chester	83
Army Reserve	78	Clemson	83
Bushy Park	76	Cowpens	88
Indian town	82	Due West	82
Sand Hill	91	Long Creek	80
Congaree Swamp	67	North SPA	83
Pee Dee	N/A	Powders ville	88
Parklane	84	York	89
Trenton	79	Delta	81
Jackson	79	Barnwell	82

* Monitors bolded in blue continue through the Episode selection steps

The Second Step of the episode selection was applied next. The top ten 8 hourly daily maximum observed ozone values for each three years (1992, 1993, & 1994) were listed for each monitors screened through Step One. The top ten ozone values were then averaged at each monitor (see Table 3a) completing the third step.

Table 3a Top 10 averages from 1992-1994 - Step 2 & 3

Monitor	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Army Reserve	87	84	80	78	77	76	75	74	74	73
Bushy Pk	87	82	78	76	74	73	72	72	71	71
Indian town	88	86	84	82	81	80	78	77	76	76
Parklane	97	88	88	84	83	83	81	78	78	77
Sand Hill	96	93	92	91	88	86	85	85	84	83
Barnwell	90	86	83	82	81	81	80	79	79	78
Jackson	88	83	80	79	78	76	75	75	74	73
Trenton	89	83	80	79	76	75	74	74	74	73
Chester	95	92	88	83	81	81	79	78	77	77
Clemson	93	88	85	83	81	81	79	78	78	77
Cowpens	97	95	91	88	86	84	82	82	80	80
Delta	89	86	84	81	78	77	76	76	75	75
Due West	87	85	84	82	79	79	77	76	76	75
Long creek	88	85	81	80	77	75	75	74	74	73
NSFS	93	89	84	83	82	80	79	77	77	77
Powdersville	101	99	91	88	83	82	81	81	80	80
York	98	95	90	89	86	83	81	79	78	78

4th high average from 1992 through 1994 shaded in orange

The 4th Step (table 4a) in the EPA protocol for selecting episodes notes values within 10 ppb of the average 4th high ozone values. This 4th step is used to select the actual ozone episodes. Once the dates and ozone values were selected using step four, the dates were then examined and classified into meteorological regimes. This method resulted in July 21st through July 30th being selected as the ozone episode for 1993.

Table 4a Range + or - 10 ppb from the 4th highest value

Army Res	Bushy Pk	Indian	Parklane	Sandhill	Barnwell	Jackson	Trenton	Chester
68 to 88	66 to 86	72 to 92	74 to 94	81 to 101	72 to 92	69 to 89	69 to 89	73 to 93

Clemson	Cowpens	Delta	Due West	Long Cr	N.Spartan	Powders	York
73 to 93	78 to 98	71 to 91	72 to 92	70 to 90	73 to 93	78 to 98	79 to 99

Table 5a provides an example of the classification of ozone episodes into different meteorological regimes based on wind speeds and wind directions. The draft guidance recommends that episodes be chosen that reflect a variety of wind orientations. July 21st through July 30th wind data was examined carefully at each monitor. Dates and monitors were then classified by wind orientation. The results of this study can be viewed in a spread sheet stored in data bases saved on the network. A variety of wind orientations show up during this period, satisfying the recommendation by the EPA in the draft document. Because the requirements listed in the draft document were satisfied, this period was selected as an episode to model for South Carolina. An example (see Table 5a) of several of these monitors, dates, ozone levels, and wind orientations are listed below. Monitors from the three geographical areas of concern were selected for this example. Especially note the monitors that are included in this table more than once. For example, Cowpens had several days when the 8hr ozone standard was exceeded; however, the wind regimes were different on some of those days. On July 22nd, the wind speed was 6.6 mph from the southwest; however, on July 23rd, the wind direction was from the north-northeast. Since the wind switched direction almost 180 degrees on the following day, it is possible that re-circulation occurred. In addition, note the Due West monitor. An exceedence occurs on the 21st of July but does not occur on the 22nd of July during this episode; however, the 75 ppb reading falls within the 10ppb range of the design value; therefore, it is included in this listing. As one can clearly see, different wind patterns emerge on July 21st and July 22nd at this location. The York monitor represents an entirely different scenario. Notice that these large exceedences are well over 10ppb (99ppb) from the design value of 89 ppb, but these values do fall within the Ozone Episode selected. Notice that the wind regimes are different at the York county on these two dates. On July 21st, the winds are from the east-northeast while on July 28th, the winds are from the west-northwest. A complete analysis on meteorological classification of the 1993 ozone episode can be viewed in final93design file on the network.

Table 5a Ozone values and dates classified under meteorological regimes

Monitor	Ozone (ppb)	Wind Speed	Wind Direction	Date
Delta	88	6.3	40	7/21/93
Cowpens	89	6.6	240	7/22/93
Cowpens	93	6.9	30	7/23/93
Due West	85	6.3	40	7/21/93
Due West	75	6.6	240	7/22/93
Sandhill	100	4.3	180	7/22/93
Trenton	87	4.5	180	7/22/93
Trenton	87	3.0	200	7/23/93
York	118*	6.1	60	7/21/93
York	113*	5.4	320	7/28/93

Note the Pink Shading for the York monitor. This indicates that the ozone values exceeds 10ppb from the design value at this particular monitor.

Ozone Episode Selection for 1996

The EPA guidance for selecting ozone episodes was repeated for 1996. Once again, design values were calculated for each of these two years. Screening was based on a 75 ppb level, or 10ppb below the 85ppb eight hour standard. Notice the difference in design values for 1993 and 1996. (see Table 2a and Table 2b). Only two monitors were screened out in 1993 while ten monitors were screened out in 1996. In addition, the design values in 1996 are significantly lower than those in 1993.

Table 2b Design Values for 1996 - Step I

Monitors	1996 Design Values	Monitors	Design Value
Cape Romain	73	Chester	85
Army Reserve	64	Clemson	82
Bushy Park	67	Cowpens	82
Indian town	67	Due West	74
Sand Hill	79	Long Creek	76
Congaree Swamp	67	North SPA	85
Pee Dee	74	Powders ville	83
Parklane	74	York	81
Trenton	73	Delta	77
Jackson	77	Barnwell	73

* Monitors bolded in blue continue through the Episode selection steps

The second step of the episode selection was applied next. The top ten 8 hourly daily maximum observed ozone values for each three years (1995 through 1997) were listed for each monitors screened through step one. The top ten ozone values were then averaged at each monitor (see Table 3b) completing the third step.

Table 3b Top Ten Averages from 1995-1997 -Step 2 and 3

95-97 avg	Jackson	Chester	Clemson	Cowpens	Delta	Long creek	N.Spartan	Powdersville	York	Sandhill
1st High	0.084	0.093	0.091	0.088	0.087	0.082	0.095	0.093	0.094	0.093
2nd High	0.083	0.090	0.088	0.083	0.080	0.081	0.090	0.089	0.088	0.085
3rd High	0.077	0.088	0.082	0.083	0.078	0.079	0.088	0.087	0.084	0.080
4th High	0.077	0.085	0.082	0.082	0.077	0.076	0.085	0.083	0.081	0.079
5th High	0.075	0.083	0.080	0.080	0.072	0.075	0.082	0.081	0.079	0.077
6th High	0.074	0.082	0.079	0.079	0.072	0.074	0.081	0.079	0.078	0.076
7th High	0.071	0.081	0.078	0.078	0.070	0.074	0.080	0.078	0.077	0.075
8th High	0.071	0.079	0.077	0.077	0.070	0.073	0.079	0.078	0.077	0.074
9th High	0.071	0.078	0.076	0.077	0.069	0.072	0.078	0.078	0.076	0.074
10th High	0.070	0.077	0.076	0.076	0.069	0.071	0.077	0.077	0.074	0.072

4th high average from 1995 through 1997 shaded in orange

* pink shadings indicate monitors that are screened out assuming the standard is 90ppb

The 4th step in the EPA protocol for selecting episodes note values within 10 ppb of the average 4th high ozone values. This 4th step is used to select the actual ozone episodes in 1996. Once the dates and ozone values were selected using step four, the dates selected were then examined and classified into meteorological regimes (Table 4b).

Table 4b Step 4 + or - 10 ppb of the 4th high avg.

Jackson	Chester	Clemson	Cowpens	Delta	Long creek	N.Spartan	Powders	York	Sandhill
67 to 87	75 to 95	72 to 92	72 to 92	67 to 87	66 to 86	75 to 95	73 to 93	71 to 91	69 to 89

Table 5b provides an example of the classification of ozone episodes into different meteorological regimes based on wind speeds and wind directions. The draft guidance recommends that episodes be chosen that reflect a variety of wind orientations. Using this method, July 27th through July 30th was examined. Dates and monitors were then classified by wind orientation. The results can be viewed in an excel spreadsheet in our database stored on the network. It should be noted that only one exceedences of the 8 hour standard occurred during this whole episode. Due to the lack of data (which results in from low ozone levels), it is not plausible to complete the last step in choosing an episode. Because 1995 and 1996 were anomously low ozone years, the method recommended by the EPA in the draft guidance does not result in a true ozone episode for South Carolina in 1996.

Table 5b Classification of Meteorological Regimes for 1996 Episodes

Monitor	Ozone (ppb)	Wind Speed	Wind Direction	Date
Sandhill	89	4.8	80	8/30/96
Sandhill	73	3.7	130	8/27/96

Using a hypothetical 90ppb 8 hour Standard for 1996

In addition, an analysis was done assuming the 8hr standard was changed from 85 ppb to 90 ppb. This results in a higher screening value used in step one. As one can see below in Table 6b, when using an 80 ppb value to screen, additional monitors dropped out of the process. Jackson, Long Creek, Delta, and Sandhill were all screened out of the next steps; therefore, return to steps 2 through 7 above without the monitors listed above.

Table 6b Design Values with 80ppb Screening for 1996

Monitors	1996 Design Values	Monitors	Design Value
Cape Romain	73	Chester	85
Army Reserve	64	Clemson	82
Bushy Park	67	Cowpens	82
Indian town	67	Due West	74
Sand Hill	79	Long Creek	76
Congaree Swamp	67	North SPA	85
Pee Dee	74	Powders ville	83
Parklane	74	York	81
Trenton	73	Delta	77
Jackson	77	Barnwell	73

* Monitors bolded in blue continue through the Episode selection steps

* Monitors shaded in pink screen out of process due to higher design values based on a hypothetical 90 ppb standard

Ozone Episode Selection for 1997

The EPA guidance for selecting ozone episodes was repeated for 1997. Once again, design values were calculated for each of these two years. Screening is based on a 75 ppb level or 10ppb below the 85ppb eight hour standard. Design values for 1997 increased due to the weighing in of 1998 ozone data; however, the values are lower than the 1993 design values (see Table 2a, Table 2b and Table 2c). Cape Romain, Bushy Park, Army Reserve, Indian town, and Congaree Swamp dropped out of the analysis using the 75ppb screening in 1997.

Table 2c Design Values with 75 ppb for screening

Monitors	1997 Design Values	Monitors	Design Value
Cape Romain	73	Chester	87
Army Reserve	67	Clemson	87
Bushy Park	72	Cowpens	85
Indian town	69	Due West	76
Sand Hill	84	Long Creek	81
Congaree Swamp	69	North SPA	88
Pee Dee	80	Powders ville	87

Parklane	79	York	81
Trenton	81	Delta	78
Jackson	84	Barnwell	81

* Blue shading represents monitors that continue through the process

The second step of the episode selection was applied next. The top ten 8 hourly daily maximum observed ozone values for each three years (1996 through 1998) were listed for each monitors then averaged to complete the third step (see Table 3c)

Table 3c Top Ten Averages from 1996-1998 - Steps 2 & 3

96-98 avg	Jackson	Barnwell	Sandhill	Parklane	Pee Dee	Chester	Clemson
1st High	0.091	0.091	0.099	0.088	0.089	0.097	0.093
2nd High	0.089	0.085	0.090	0.085	0.081	0.091	0.090
3rd High	0.085	0.082	0.086	0.080	0.080	0.089	0.088
4th High	0.084	0.081	0.084	0.079	0.080	0.087	0.087
5th High	0.083	0.081	0.083	0.078	0.078	0.085	0.086
6th High	0.082	0.080	0.082	0.077	0.076	0.084	0.083
7th High	0.081	0.079	0.080	0.074	0.076	0.083	0.081
8th High	0.080	0.078	0.079	0.074	0.076	0.081	0.080
9th High	0.079	0.078	0.078	0.073	0.074	0.081	0.078
10th High	0.078	0.075	0.077	0.072	0.074	0.079	0.077

Table 3c Continued Top Ten Averages from 1996-1998- Steps 2 & 3

96-98 avg	Cowpens	Delta	Due West	Long Cr	NSFS	Pwdrsville	Trenton	York
1st High	0.089	0.089	0.089	0.087	0.095	0.097	0.092	0.090
2nd High	0.087	0.080	0.083	0.086	0.090	0.092	0.084	0.086
3rd High	0.086	0.079	0.079	0.085	0.090	0.089	0.082	0.083
4th High	0.085	0.078	0.076	0.081	0.088	0.087	0.081	0.081
5th High	0.083	0.077	0.075	0.080	0.084	0.085	0.079	0.079
6th High	0.081	0.076	0.075	0.080	0.083	0.083	0.076	0.078
7th High	0.081	0.075	0.075	0.079	0.082	0.082	0.076	0.077
8th High	0.080	0.074	0.075	0.078	0.081	0.080	0.075	0.077
9th High	0.080	0.074	0.074	0.078	0.081	0.080	0.074	0.076
10th High	0.079	0.074	0.074	0.077	0.080	0.079	0.074	0.07

* 4th high average from 1996 through 1998 shaded in orange

**Purple shadings represent monitors that are screened out the process assuming a new standard of 90 ppb

The 4th step in the EPA protocol for selecting episodes note values within 10 ppb of the average 4th high ozone values. This 4th step was used to select the actual ozone episodes in 1997. Once the dates and ozone values were selected using step four, the values were then examined and classified into meteorological regimes (Table 4c).

Table 4c Step 4 Range + or - 10 ppb from the 4th highest value

Jackson	Barnwell	Sandhill	Parklane	Pee Dee	Chester	Clemson	Cowpens
74 to 94	71 to 91	74 to 94	69 to 89	70 to 90	77 to 97	77 to 97	75 to 95

Delta	Due West	Long C	N. Spart	Powders	Trenton	York
68 to 88	66 to 86	71 to 91	78 to 98	77 to 97	71 to 91	71 to 91

This method resulted in July 8th through July 14th as being selected as the ozone episode for 1997. Table 5c provides an example of the classification of ozone episodes into different meteorological regimes based on wind speeds and wind directions. The draft guidance recommends an episode be chosen that reflect a variety of wind orientations. July 8th through July 14th wind data was examined carefully and at each monitor. Dates and monitors were classified by wind orientation following step five in the EPA draft guidance. The results can be viewed in an excel spreadsheet. A variety of wind orientations occurred during this period which satisfied the recommendation by the EPA in the draft document. Several of these monitors, dates, ozone levels, and wind orientations were chosen for examples(Table 5c) . Monitors from geographical areas of concern were selected for this example. Especially note the monitors that are in this table more than once. For example, Chester had several days when the 8hr ozone standard was exceeded; however, the wind regimes were different on some of the days. On July 8th, the wind speed was 3.0 mph from the south-southwest; however, on July 12th, the wind direction was from the east-northeast. In addition, note the N. Spartanburg monitor. On July 8th, a 3.0 mph south-southwesterly wind occurred on an exceedences day. On the 12th of July, an east-northeasterly wind occurred on an exceedence day. This is a good example of two different wind regimes that resulted in exceedence of the 8 hr standard.

Table 5c Meteorological Regimes for 1997

Monitor	Ozone (ppb)	Wind Speed	Wind Direction	Date
Chester	87	3.0	210	7/08/97
Chester	97	3.0	60	7/12/97
N.Spartanburg	89	3.0	210	7/08/97
N.Spartanburg	94	3.0	60	7/12/97
Barnwell	85	1.9	190	7/14/97

* Red shading indicates an exceedences of the 8hr standard

Using a hypothetical 90ppb 8 hour Standard for 1997

In addition, an analysis was completed assuming the 8hr standard was changed from 85 ppb to 90 ppb which resulted in a change in the screening value. As one can see below in Table 6c, using 80 ppb value to screen with would result in several additional monitors being screened out of the process. As one can see, Due West, Delta, and Parklane were screened out of the next steps assuming a 90 ppb standard.

Table 6c Design Values with 80ppb Screening for 1997

Monitors	1997 Design Values	Monitors	Design Value
Cape Romain	73	Chester	86
Army Reserve	67	Clemson	87
Bushy Park	72	Cowpens	85
Indian town	69	Due West	76
Sand Hill	84	Long Creek	81
Congaree Swamp	69	North SPA	88
Pee Dee	80	Powders ville	87
Parklane	79	York	81
Trenton	81	Delta	77
Jackson	84	Barnwell	81

* Blue shadings represent monitors that continue through the process assuming the new standard is 90ppb

* Monitors shaded in pink screen out of process due to higher design values based on a hypothetical 90 ppb standard

Selection of Ozone Episodes from 1998

Using the EPA's procedure on the 1998 ozone data yielded a rich data set for ozone modeling. The 1998 ozone season was the worst on record due to a hot, dry, and stagnant summer-time weather pattern. In addition, the 1997 and 1999 ozone seasons were more severe than normal. All these factors combined lead to high design values for 1998. The EPA guidance for selecting ozone episodes was repeated for 1998. Once again, design values were calculated for each of these two years. Screening was based on a 75 ppb level, or 10ppb below the 85ppb eight hour standard. Design values for 1998 are high, and all of the monitors had design values over 75 ppb; therefore, all monitors were considered using the EPA seven step method. (see Table 2d below)

Table 2d Design Values with 75 ppb Screening for 1998

Monitors	1998 Design Values	Monitors	Design Value
Cape Romain	80	Chester	93
Army Reserve	76	Clemson	92
Bushy Park	79	Cowpens	93
Indian town	76	Due West	87
Sand Hill	91	Long Creek	87
Congaree Swamp	76	North SPA	96
Pee Dee	90	Powders ville	96
Parklane	93	York	87
Trenton	89	Delta	85
Jackson	89	Barnwell	88

* blue shadings represent monitors at or above 75 ppb

* pink shadings represent monitors that are screened out if hypothetical 90 ppb standard proposed

The second step of the Episode selection was applied next. The top eight hourly averaged maximum, observed values for each of the three years (1997-1999) were listed for each of the monitors then averaged to complete the third step (see Table 3d).

Table 3d Top Ten Averages from 1997-1999 - Steps 2 & 3

	Cape	Army Res	Ashton	Indian	PeeDee	Congaree	Parklane
1st avg	86	85	87	81	97	84	102

2nd avg	86	77	86	78	91	78	98
3rd avg	84	77	84	78	90	77	94
4th avg	80	76	83	76	89	76	94
5th avg	78	75	83	75	88	74	91
6th avg	75	74	81	73	86	73	89
7th avg	74	72	80	72	86	69	88
8th avg	73	72	80	72	86	72	87
9th avg	73	71	79	71	83	71	86
10th avg	72	70	78	70	83	70	84

Table 3d continued Top Ten Averages from 1997-1999 - Steps 2 & 3

	Sandhill	Clemson	Chester	Cowpens	Delta	Due West	Long C
1st avg	103	100	109	100	95	96	93
2nd avg	97	97	96	98	88	91	91
3rd avg	94	95	94	94	86	90	90
4th avg	91	92	93	93	85	87	87
5th avg	91	90	91	90	84	87	86
6th avg	89	87	90	88	83	86	86
7th avg	86	86	89	88	82	85	85
8th avg	85	85	89	87	81	84	84
9th avg	84	83	89	86	81	84	84
10th avg	84	82	87	85	81	83	83

Table 3d continued Top Ten Averages from 1997-1999 - Steps 2 & 3

	N.Sparta	Powders	Trenton	Jackson	Barnwell	York	Bushy P
1st avg	103	109	101	99	96	97	88
2nd avg	97	102	93	95	93	92	86
3rd avg	97	99	90	90	90	90	83
4th avg	96	96	89	89	88	87	79
5th avg	92	94	87	88	88	85	78
6th avg	89	92	84	87	87	84	78
7th avg	88	91	84	87	85	82	76
8th avg	86	88	82	86	85	82	76
9th avg	85	88	81	85	84	81	75
10th avg	84	87	81	84	82	80	74

Pink Shading represent monitors that fall out of the process when screening value is 80 ppb

The fourth step in the EPA protocol states that all eight hour ozone averages within ten parts per billion of the fourth average high at each monitor should be noted. Table 4b shows the range of values noted at each monitor. This step was used to select ozone values and dates for Urban Air Shed modeling. Once these dates were selected, they were classified by meteorological conditions with emphasis on the wind parameters.

Table 4d Range + or - 10 ppb from the 4th highest value

Cape Romain	Army Reserve	Bushy Park	Jackson	Barnwell	Congaree	Sand Hill	Parklane
70 to 90	66 to 86	69 to 89	79 to 99	78 to 98	66 to 86	81 to 101	83 to 103

Chester	Clemson	Cowpens	Long Creek	.N.Spartan	Powders	Pee Dee

83 to 103	82 to 102	83 to 103	83 to 103	86 to 106	86 to 106	80 to 100
-----------	-----------	-----------	-----------	-----------	-----------	-----------

York	Ashton	Delta	Indian
77 to 97	73 to 93	75 to 95	69 to 89

The 1998 Ozone Episodes

Seven ozone episodes were selected and examined for the 1998 season. Using the EPA ozone selection procedure, the dates shaded in pink represent days in which the maximum eight hour average ozone levels were within 10 parts per billion of the design values for that particular site. The first ozone episode in 1998 occurred from May 15th through May 22nd. The chart below divides SC into four regions (Coastal, Midlands, Upstate, & CSRA). This helps to identify the regional impact of the ozone episode. Note in particular the widespread impact of the first ozone episode; all regions of the area were impacted by this early season event. During this period, a stagnant, flat upper-ridge was centered over the Gulf of Mexico extending northward into the Deep South and Southeast. This position of the upper-high cut off the normal Gulf moisture, and as a result SC was unseasonably hot and dry.

1998 Ozone Episode 1

Cape Romain	15-May	16-May	17-May	18-May	19-May	20-May	21-May	22-May
Army Reserve	15-May	16-May	17-May	18-May	19-May	20-May	21-May	22-May
Ashton	15-May	16-May	17-May	18-May	19-May	20-May	21-May	22-May
Bushy	15-May	16-May	17-May	18-May	19-May	20-May	21-May	22-May
Indian	15-May	16-May	17-May	18-May	19-May	20-May	21-May	22-May
Coastal %	40%	80%	20%	80%	60%	80%	80%	C80%
Sandhill	15-May	16-May	17-May	18-May	19-May	20-May	21-May	22-May
Parklane	15-May	16-May	17-May	18-May	19-May	20-May	21-May	22-May
Congaree	15-May	16-May	17-May	18-May	19-May	20-May	21-May	22-May
Pee dee	15-May	16-May	17-May	18-May	19-May	20-May	21-May	22-May
Midlands %	50%	50%	0%	25%	100%	75%	75%	25%
Chester	15-May	16-May	17-May	18-May	19-May	20-May	21-May	22-May
Clemson	15-May	16-May	17-May	18-May	19-May	20-May	21-May	22-May
Cowpens	15-May	16-May	17-May	18-May	19-May	20-May	21-May	22-May
Delta	15-May	16-May	17-May	18-May	19-May	20-May	21-May	22-May
Due West	15-May	16-May	17-May	18-May	19-May	20-May	21-May	22-May
Longcreek	15-May	16-May	17-May	18-May	19-May	20-May	21-May	22-May
N Spartanburg	15-May	16-May	17-May	18-May	19-May	20-May	21-May	22-May

Sandhill	21-Jun	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun
Parklane	21-Jun	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun
Congaree	21-Jun	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun
Pee dee	21-Jun	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun
Midlands %	25%	25%	25%	25%	25%	75%	75%	0%
Chester	21-Jun	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun
Clemson	21-Jun	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun
Cowpens	21-Jun	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun
Delta	21-Jun	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun
Due West	21-Jun	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun
Longcreek	21-Jun	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun
N Spartanburg	21-Jun	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun
Powdersville	21-Jun	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun
York	21-Jun	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun
Upstate %	0%	0%	0%	22%	44%	22%	0%	0%
Barnwell	21-Jun	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun
Jackson	21-Jun	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun
Trenton	21-Jun	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun
CSRA %	33%	67%	33%	33%	67%	33%	33%	33%
Total %	14%	24%	19%	33%	48%	43%	29%	19%

*Red Shading indicate dates when ozone levels were within 10 pbb of the design value at that particular monitor

* % of monitors having ozone levels within 10 pbb for that particular region

Table 5d lists several examples of wind classification from Episode two. The monitors in the example below were listed twice showing different wind regimes. A complete analysis of all of the monitors and their classifications can be found on the network.

Table 5d Meteorological Regimes for Episode One of 1998

Bushy P	Ws	Wd	Indian	Ws	Wd	Sandhill	Ws	Wd
6/14/98	9.4	230	6/18/98	5.3	180	6/26/98	5.4	200
6/17/98	8.1	290	6/19/98	6.5	220	6/27/98	5.2	250

Italic and Underlined dates indicate ozone levels are or above the 8hr standard on that date

The third and fourth ozone episodes occurred in early July and was confined primarily to the coastal and central portions of SC. The pattern during this episode changed a bit with the Bermuda high dominating much of the Eastern half of the US. The core of the upper-high was located to the north of the region during much of this period and gradually shifted eastward by the end of this period.

1998 Ozone Episodes Three & Four (July 1st-4th & July 6th-10th)

Cape Romain	1-Jul	2-Jul	3-Jul	4-Jul	5-Jul	6-Jul	7-Jul	8-Jul	9-Jul	10-Jul
Army Reserve	1-Jul	2-Jul	3-Jul	4-Jul	5-Jul	6-Jul	7-Jul	8-Jul	9-Jul	10-Jul
Ashton	1-Jul	2-Jul	3-Jul	4-Jul	5-Jul	6-Jul	7-Jul	8-Jul	9-Jul	10-Jul
Bushy	1-Jul	2-Jul	3-Jul	4-Jul	5-Jul	6-Jul	7-Jul	8-Jul	9-Jul	10-Jul

Indian	1-Jul	2-Jul	3-Jul	4-Jul	5-Jul	6-Jul	7-Jul	8-Jul	9-Jul	10-Jul
Coastal %	60%	60%	80%	40%	0%	0%	40%	60%	60%	60%
Sandhill	1-Jul	2-Jul	3-Jul	4-Jul	5-Jul	6-Jul	7-Jul	8-Jul	9-Jul	10-Jul
Parklane	1-Jul	2-Jul	3-Jul	4-Jul	5-Jul	6-Jul	7-Jul	8-Jul	9-Jul	10-Jul
Congaree	1-Jul	2-Jul	3-Jul	4-Jul	5-Jul	6-Jul	7-Jul	8-Jul	9-Jul	10-Jul
Pee dee	1-Jul	2-Jul	3-Jul	4-Jul	5-Jul	6-Jul	7-Jul	8-Jul	9-Jul	10-Jul
Midlands %	25%	25%	50%	0%	0%	50%	75%	25%	25%	75%
Chester	1-Jul	2-Jul	3-Jul	4-Jul	5-Jul	6-Jul	7-Jul	8-Jul	9-Jul	10-Jul
Clemson	1-Jul	2-Jul	3-Jul	4-Jul	5-Jul	6-Jul	7-Jul	8-Jul	9-Jul	10-Jul
Cowpens	1-Jul	2-Jul	3-Jul	4-Jul	5-Jul	6-Jul	7-Jul	8-Jul	9-Jul	10-Jul
Delta	1-Jul	2-Jul	3-Jul	4-Jul	5-Jul	6-Jul	7-Jul	8-Jul	9-Jul	10-Jul
Due West	1-Jul	2-Jul	3-Jul	4-Jul	5-Jul	6-Jul	7-Jul	8-Jul	9-Jul	10-Jul
Longcreek	1-Jul	2-Jul	3-Jul	4-Jul	5-Jul	6-Jul	7-Jul	8-Jul	9-Jul	10-Jul
N Spartanburg	1-Jul	2-Jul	3-Jul	4-Jul	5-Jul	6-Jul	7-Jul	8-Jul	9-Jul	10-Jul
Powdersville	1-Jul	2-Jul	3-Jul	4-Jul	5-Jul	6-Jul	7-Jul	8-Jul	9-Jul	10-Jul
York	1-Jul	2-Jul	3-Jul	4-Jul	5-Jul	6-Jul	7-Jul	8-Jul	9-Jul	10-Jul
Upstate %	0%	0%	22%	0%	0%	44%	11%	0%	0%	22%
Barnwell	1-Jul	2-Jul	3-Jul	4-Jul	5-Jul	6-Jul	7-Jul	8-Jul	9-Jul	10-Jul
Jackson	1-Jul	2-Jul	3-Jul	4-Jul	5-Jul	6-Jul	7-Jul	8-Jul	9-Jul	10-Jul
Trenton	1-Jul	2-Jul	3-Jul	4-Jul	5-Jul	6-Jul	7-Jul	8-Jul	9-Jul	10-Jul
Total %	0%	67%	33%	33%	0%	33%	0%	0%	33%	67%

*Purple Shading indicate dates in which ozone levels were within 10 ppb of the design value at that particular monitor

* % of monitors having ozone levels within 10 ppb for that particular region

Table 5e lists several monitors with different wind parameters. For example, the Pee Dee monitor had an ozone level within 10 ppb of the design value on the 6th and again on the 10th of July; however, wind parameters were different. On July 6th, the wind speed was 7.8 mph from the northeast and on the 10th, the wind speed was 5.8 mph from the northwest. This example demonstrates the requirement that days be selected at each monitor with different wind parameters.

Table 5e Meteorological Regimes for Episode Two of 1998

Congaree	Ws	Wd	Pee Dee	Ws	Wd
7/1/98	9.5	290	7/6/98	7.8	60
7/3/98	3.7	30	7/7/98	4.5	130
7/6/98	7.8	60	7/8/98	8.9	240
7/7/98	4.5	130	7/10/98	5.8	350

The fourth ozone episode primarily affected the Upstate and the Midlands. The event occurred from August 19th through August 26th in the Upstate, and affected the Midlands from August 22nd through August 24th. During this period, an upper high was centered just to the north of SC during the beginning of the period then shifted north and west of SC during the end of the period. A weak, back-door cool front (dry line) crossed the state from north to south on the 19th and 20th with the surface high building in from the north. Hurricane Bonnie was located

off the Southeast coast on the 25th and near the NC coast on the 26th. This provided more subsidence for western sections of the region.

1998 The Fifth Ozone Episode

Cape Romain	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug
Army Reserve	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug
Ashton	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug
Bushy	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug
Indian	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug
Coastal %	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sandhill	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug
Parklane	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug
Congaree	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug
Pee dee	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug
Midlands%	0%	0%	0%	100%	75%	25%	0%	0%	0%
Chester	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug
Clemson	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug
Cowpens	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug
Delta	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug
Due West	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug
Longcreek	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug
N Spartanburg	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug
Powdersville	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug
York	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug
Upstate %	22%	11%	78%	100%	44%	44%	67%	22%	0%
Barnwell	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug
Jackson	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug
Trenton	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug
CSRA %	0%	0%	33%	33%	33%	0%	0%	33%	0%

*Green Shading indicate dates in which ozone levels were within 10 ppb of the design value at that particular monitor

* % of monitors having ozone levels within 10 ppb for that particular region

Table 5 f gives examples of monitors classified by wind direction and wind speed for Episode five. Note the Due West monitor. On August 24th, the Due West monitor had a 8 hour average ozone level within 10 ppb of the design value which was also over the 85 ppb 8 hour average ozone standard. Once again, note the Due West monitor on the 26th of August. The 8 hour ozone average at Due West was within ten ppb of the Design value, but this time the 8 hr ozone average was below the 85 ppb standard. The wind parameters between these two days did not have any similarity with a 4.6 mph wind from the south-southwest on the 24th and a 9.3 mph north, northeast wind on the 26th of August. This provides an excellent example of different wind regimes on high ozone days at a particular monitor.

Table 5f Meteorological Regimes for Episode Four of 1998

Cowpens	Ws	Wd	Delta	Ws	Wd	Due West	Ws	Wd
8/21/98	3.5	90	8/30/98	5.5	60	8/24/98	4.6	220

<u>8/22/98</u>	<u>2.4</u>	<u>110</u>	<u>8/31/98</u>	<u>6.2</u>	<u>60</u>	<u>8/26/98</u>	<u>9.3</u>	<u>20</u>
----------------	------------	------------	----------------	------------	-----------	----------------	------------	-----------

Italic and Underlined dates indicate ozone levels are or above the 8hr standard on that date

The sixth episode occurred primarily in the Upstate and Central Savannah River area. This episode began on the 28th of August and continued through August 31st. Hurricane Bonnie was located off the Virginia coast on the 28th and accelerating northward. High pressure was centered over eastern Ky. In the upper-levels a ridge of high pressure was centered over the Southeast. A weak and dying surface front slipped southward to NC on August 30th.

1998 Ozone Episode Six

Cape Romain	28-Aug	29-Aug	30-Aug	31-Aug
Army Reserve	28-Aug	29-Aug	30-Aug	31-Aug
Ashton	28-Aug	29-Aug	30-Aug	31-Aug
Bushy	28-Aug	29-Aug	30-Aug	31-Aug
Indian	28-Aug	29-Aug	30-Aug	31-Aug
Coastal %	40%	0%	0%	20%
Sandhill	28-Aug	29-Aug	30-Aug	31-Aug
Parklane	28-Aug	29-Aug	30-Aug	31-Aug
Congaree	28-Aug	29-Aug	30-Aug	31-Aug
Pee dee	28-Aug	29-Aug	30-Aug	31-Aug
Midlands %	0%	25%	0%	75%
Chester	28-Aug	29-Aug	30-Aug	31-Aug
Clemson	28-Aug	29-Aug	30-Aug	31-Aug
Cowpens	28-Aug	29-Aug	30-Aug	31-Aug
Delta	28-Aug	29-Aug	30-Aug	31-Aug
Due West	28-Aug	29-Aug	30-Aug	31-Aug
Longcreek	28-Aug	29-Aug	30-Aug	31-Aug
N Spartanburg	28-Aug	29-Aug	30-Aug	31-Aug
Powdersville	28-Aug	29-Aug	30-Aug	31-Aug
York	28-Aug	29-Aug	30-Aug	31-Aug
Upstate %	11%	67%	56%	33%
Barnwell	28-Aug	29-Aug	30-Aug	31-Aug
Jackson	28-Aug	29-Aug	30-Aug	31-Aug
Trenton	28-Aug	29-Aug	30-Aug	31-Aug
CSRA %	33%	66%	66%	33%

*Green Shading indicate dates in which ozone levels were within 10 pbb of the design value at that particular monitor

* % of monitors having ozone levels within 10 pbb for that particular region

Table 5g is taken from the excel spreadsheet to give an example of classification of wind speeds and directions from Episode Six. Once again, a variety of wind classifications are shown satisfying the EPA guidance. Interestingly enough, both of these monitors in this example were from the same region (Central Savannah River area), both having exceeded the 8 hour ozone standard on both days with the same wind parameters. This example serves as an excellent analysis of a particular ozone episode on a regional level.

Table 5g Meteorological Regimes for Episode Five of 1998

Jackson	Ws	Wd	Barnwell	Ws	Wd
<u>8/29/98</u>	<u>4.3</u>	<u>240</u>	<u>8/29/98</u>	<u>4.3</u>	<u>240</u>
<u>8/30/98</u>	<u>2.9</u>	<u>120</u>	<u>8/30/98</u>	<u>2.9</u>	<u>120</u>

Italic and Underlined dates indicate ozone levels are or above the 8hr standard on that date

Finally, the seventh episode occurred from September 11th through September 14th (on next page in blue shading). An area of stacked high pressure was located over the central and Eastern US with the surface high over western VA on the 11th and the upper-ridge centered over the central US with a sharp trough off the New England coast. Tropical Storm Francis was moving onshore to Texas on the 11th. On the 12th and 13th, the surface high was centered on top of the area with the upper-ridge centered to the northwest. The remains of Francis moved very little over the lower plains. As noted, September 12th and 13th featured the most hits of ground-level ozone and this would coincide with the surface high being centered on top of the area.

1998 Ozone Episode Seven

Cape Romain	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep
Army Reserve	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep
Ashton	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep
Bushy	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep
Indian	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep
	60%	100%	40%	0%	0%
Sandhill	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep
Parklane	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep
Congaree	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep
Pee dee	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep
	50%	50%	20%	0%	0%
Chester	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep
Clemson	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep
Cowpens	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep
Delta	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep
Due West	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep
Longcreek	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep
N Spartanburg	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep
Powdersville	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep
York	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep
	33%	67%	67%	22%	0%
Barnwell	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep
Jackson	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep
Trenton	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep
	0%	75%	25%	0%	0%

*Blue Shading indicate dates in which ozone levels were within 10 ppb of the design value at that particular monitor
 * % of monitors having ozone levels within 10 ppb for that particular region

Using a hypothetical 90ppb 8 hour Standard for 1998

In addition, an analysis was completed assuming the 8hr standard was changed from 85 ppb to 90 ppb which resulted in a change in the screening value. As one can see below in Table 6c, using 80 ppb resulted in four monitors dropping out of the process. Army Reserve, Bushy Park, Indian Town, and Congaree Swamp were screened out of the process. The same steps above would apply only to the monitors in blue shading if the standard were to be pushed up to 90ppb.

Table 6c Design Values with 80ppb Screening for 1998

Monitors	1998 Design Values	Monitors	Design Value
Cape Romain	80	Chester	93
Army Reserve	76	Clemson	92
Bushy Park	79	Cowpens	93
Indian town	76	Due West	87
Sand Hill	91	Long Creek	87
Congaree Swamp	76	North SPA	96
Pee Dee	90	Powders ville	96
Parklane	93	York	87
Trenton	89	Delta	85
Jackson	89	Barnwell	88

* blue shadings represent monitors that continue through the process with the hypothetical 90 ppb

* pink shadings drop out of the process with the higher screening value

Conclusion

Using the EPA's guidance on ozone selection, it has been determined that 1998 yields a variety of ozone episodes. Seven different ozone episodes were identified in 1998. In these seven episodes, a variety of wind directions and wind speeds for each monitor was noted. It

should be noted that 1998 alone provides more high ozone days and a wider selection of wind regimes than all the other years combined; therefore, the 1998 ozone episodes should be considered for Urban Air Shed Modeling. It is suggested that Ozone Episode One, May 15th through May 22nd be used as an example of a statewide Ozone Episode. The second ozone episode, June 21st through June 28th could be considered for the Coastal, CSRA (Central Savannah River Area), and Midlands Ozone Episode. The third ozone episode, July 1st through July 4th, could serve as an example of a coastal event, and July 6th through the 10th (the fourth episode) could serve as an ozone episode for the Midlands and Coastal areas of SC. The fifth episode, August 20th through August 26th, could be modeled for an Upstate Ozone Episode while August 28th through August 31st could serve as an Upstate and/or CSRA episode. Finally, September 11th through 13th could serve as another statewide ozone episode. Another approach is to simply look at the complete analysis and model for each particular monitor by looking at all of the dates in which the maximum 8 hour ozone levels were within 10 ppb of the design values.